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A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Geological Engineering

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ABSTRACT

Samples of beach sands were carefully taken, prepared, and analyzed using a Universal Stage and auxiliary equipment. Further study was made with a Microhardness Tester on sections of quartz oriented in several directions. The combined results of these studies led to the following conclusions: (1) There is a definitely preferred orientation in the sands studied, which (2) is probably due to preferred fracturing and differential abrasion.

INTRODUCTION

The purpose of this investigation is to determine the orientation of quartz grains in unconsolidated beach sands, and if possible, to determine some of the physical factors involved in producing the orientation found.

Materials for this investigation were collected on the beaches of San Luis Obispo County, California, where satisfactory conditions were to be found. The majority of the samples were taken from a long spit, which extends north of Point Buchon almost to Morro Rock; however, a few samples were taken north of Morro Rock and at Avila.

PREVIOUS WORK

There has been virtually no work done on the orientation of unconsolidated beach sands. A survey of the literature indicates the major work has been done on consolidated sands.

After his careful study of the St. Peters and Jordan sandstones, Russell G. Wayland (1939), observed that grains of highly abraded quartz, are prolate spheriods, not spheres. It was also noted that in the Jordan sandstone, the grains were 17.6% longer in the direction of the optic axis. In the authors opinion such large numbers of elongated grains could not have resulted from an original elongation, especially in such well abraded and well sorted material. Therefore, the quartz grains are probably harder in the direction of the optic axis. Analysis of petrofabric diagrams showed definite tendencies toward preferred orientation (1-99).

Richard A. Rowland (1946), working along the same line as Wayland, found the existance of a definite relationship between the longest dimension and the c-axis in quartz grains. This work was performed on several sandstones, and the results compared favorably with those of Wayland's. However, Rowland, uncovered one additional fact of importance that is, the tendency toward elongation is slightly more often parallel to the unit rhombohedron than to the prism (2-547).

Experiments published in 1942 by Earl Ingerson and Joseph L. Ramish, show "(1)... that quartz has no tendency to fracture parallel to the c-axis; (2) that elongation parallel to the c-axis is not likely to be developed by differential abrasion; (3) that fresh quartz grains show elongation parallel to the c-axis and parallel to rhombohedral faces (3-606)." "It is concluded that the elongation of quartz sand grains is due to original shape rather than to fracture and differential abrasion during transport (3-595)."

SAMPLING

Sampling the upper layer of unconsolidated and undisturbed sand grains presented a problem which was solved in the following manner. A satisfactory stretch of beach was located, that is one from which the tide had just receded. First a retaining wall was built as a precaution against encroachment by large waves. Then a thin film of "Duco Cement" was applied to a glass slide, and the slide placed "cement" side down in an oriented position as determined by a compass. The edges of each slide were oriented in a N-S direction, and the slide number placed in the northeast corner. As the slide settled upon the sand virtually no pressure is required to collect sufficient grains; the less pressure of course, the better. While the "cement" was drying and before each slide was removed, a measurement of the beach slope was taken. The slopes measured were relatively constant, ranging from 2 - 4°. When the "cement" had dried, the slides were wrapped in "Kleenex" and packed away.

Several samples were taken in dry sand to test the possible effectiveness of wind in orientation of grains. Further difficulties were observed in sampling the dry sand because of its lack of tenacity, hence the error due to disorientation may be greater than in the wet beach sands.

At the time of sampling, a steady westerly wind prevailed. The weather was slightly cold, there being the usual low intermediate fog typical of the coast at this time of year.

PREPARING THIN SECTIONS

The most singly important factor in preparing thin sections was maintaining the original orientation. Following is the procedure used to accomplish this.

(1) The slide containing the "Duco Cement" and sand was soaked in warm water until the sand, still bound in the "cement", became loosened from the slide. The "cement" and sand were then placed aside to dry, orientation still being maintained.

(2) By grinding with 600 mesh grinding compound, the slide was frosted on one side.

(3) Using a medium high heat, "lakeside" was next applied to the frosted side.

(4) The "cement" was next placed on the slide.

(5) When permeation was complete, the slide was cooled and ground. Some difficulty occurred when it was noted that the grains were being removed from the slide due to a thick veneer of "lakeside". This problem was solved by placing the slides (grain side down) on another prepared slide, then grinding off the first one (see Fig. 1).

(6) When the grains were ground thin enough they were covered with "permount" and a cover-glass. It was found necessary to allow the slide to dry

thoroughly for several days on a radiator, to prevent flowage complications.

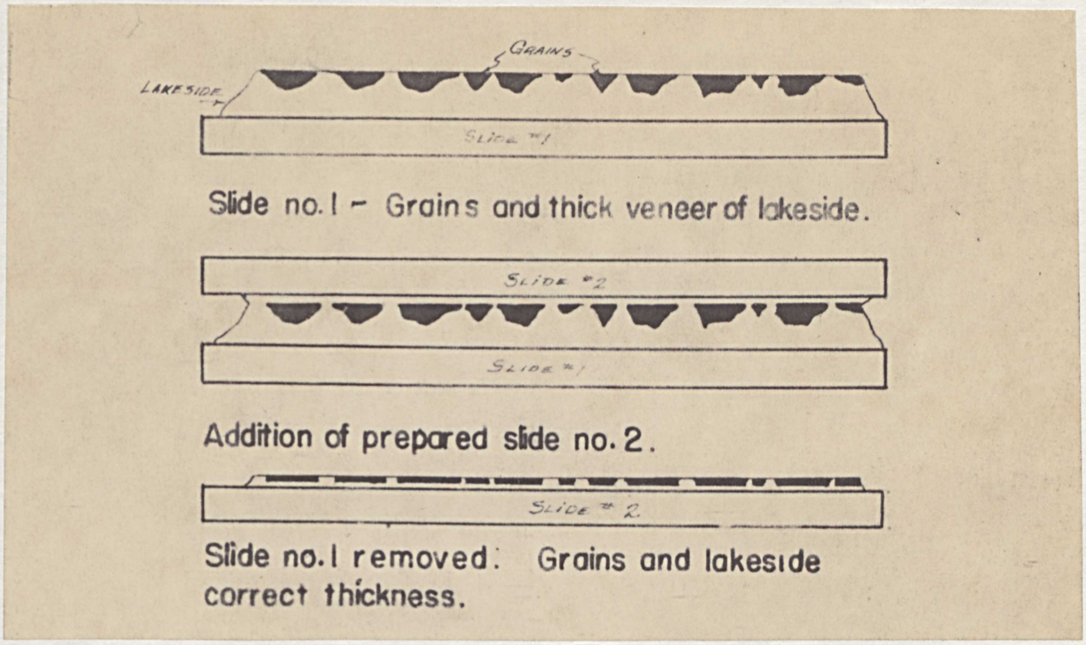


Figure No. 1
Solution of Thin Section Problem

UNIVERSAL STAGE TECHNIQUE

Universal stage techniques used in working on this problem are standard and need no further comment. For equipment used see Plate I.

When three suitable slides had been prepared work was begun. First the slides were washed in Xylene then water to insure their complete freedom from dirt and wayward "permount" and "lakeside". Next a slide was chosen and set cover-slide up in a place on the universal stage. All glass contacts must be separated by a film of chemically inert oil to prevent total reflection (4-113). Care must be taken in

Plate I

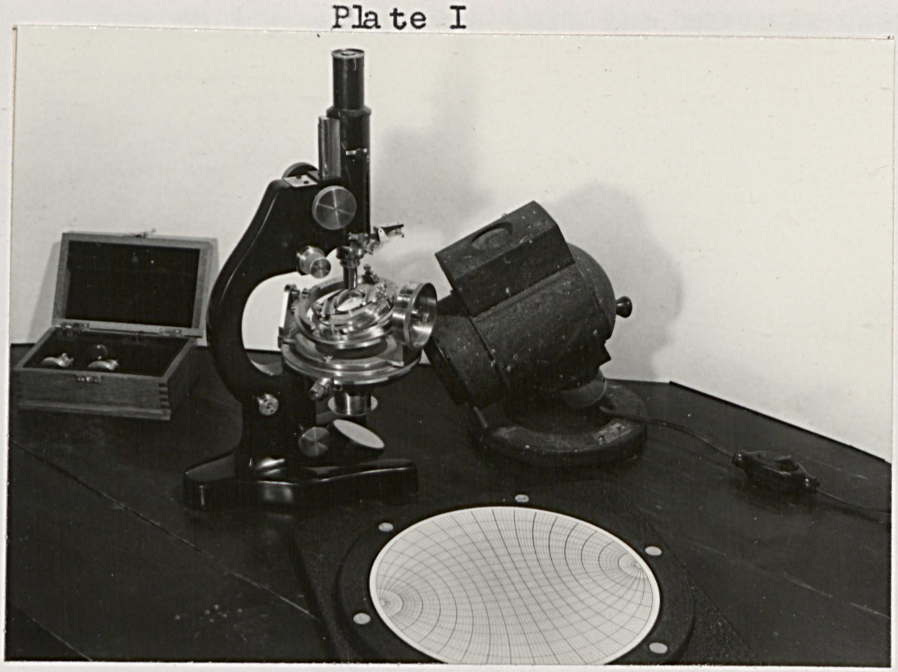


Figure A

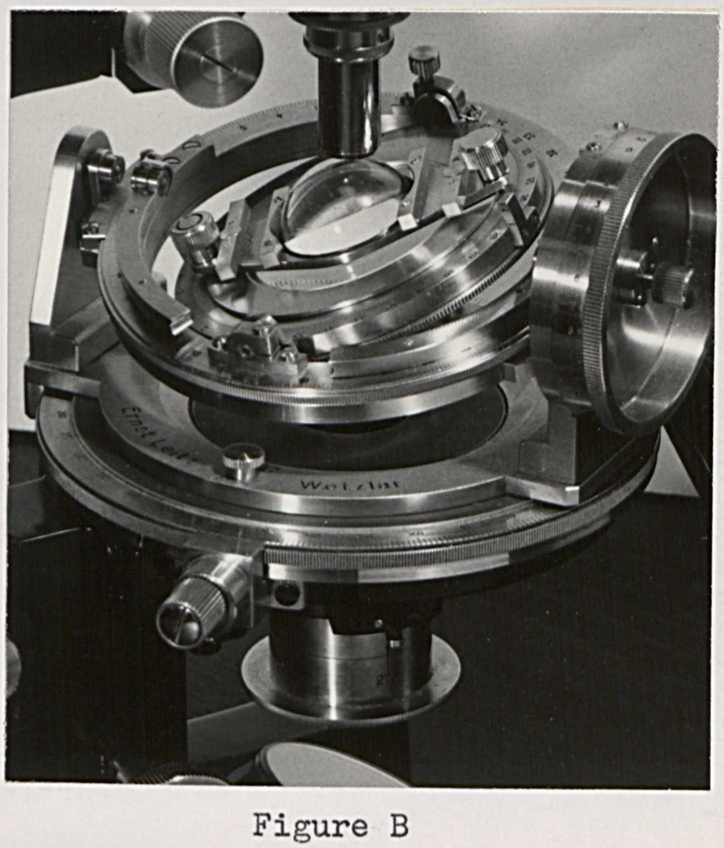


Figure B

Leitz Microscope and Universal Stage used in analyzing beach sands. Figure A. Universal Stage and Microscope with incidental equipment. Figure B. Close up of the Universal Stage.

placing the slide on the stage, so that the maximum number of grains (Microphotographs on Plate II) possible can be studied. Traverses can be accurately made with the use of the miniature carpenter's square, which fits on the upper hemisphere. New traverse positions should be taken at least every 1 mm. to prevent double readings on large grains.

When all preparations are in order, work may begin by following Fairbairn's procedure (4-114). There are times when it is inconvenient or impossible to orient a crystal parallel to the axis of the microscope; therefore, Knopf and Ingerson (1938) have worked out a procedure to orient the grain parallel to O-E-W (5-238). These procedures are standard and will not be included in this paper.

ANALYSIS OF PETROFABRIC DATA

Counting and Contouring

Following completion of the universal stage work, the tracings containing the data were "counted out" using a one-percent counter (5-246). The large number of points justified the use of this counter.

In contouring the diagrams, the total number of points were considered whole numbers so that even numbers would represent the desired percentage intervals. This procedure lessened the difficulties of contouring, but had no effect on the trend or results.

Knopf and Ingerson's (1938) counting and contouring

Plate II

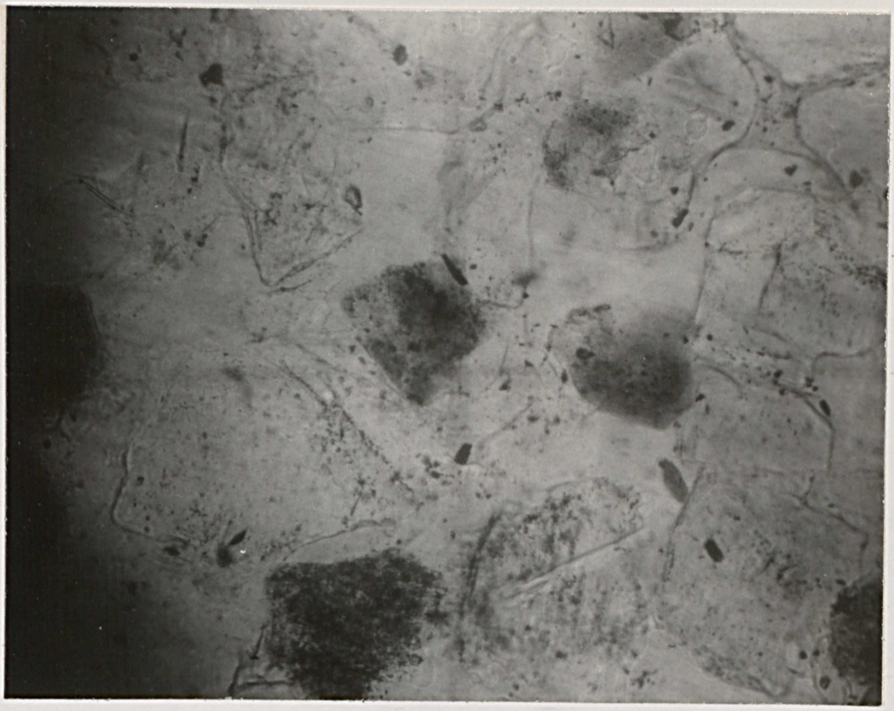


Figure A

Figure B

Microphotographs of typical thin sections. Figure A. Quartz and biotite (x 65). Figure B. X Nichols (x 65).

methods were found to be highly satisfactory (5-245).

Results

From the beach sands investigated in this study a definite preferred orientation was determined. The fabric patterns are shown in Plate III. Each sample shows similar orientations. In all three diagrams the high concentrations, (4% plus) represent broken girdle patterns, and concentration is noticeably lacking in the center and peripheral regions. Slide No. 19 is unusual in its high concentration of 6%, and also in the distinctive girdle pattern it exhibits. This pattern shows three areas of high concentration alternating with three areas of a lower concentration. Sample No. 20 is more erratic than the others, probably due to the fact that the sand sampled was dry.

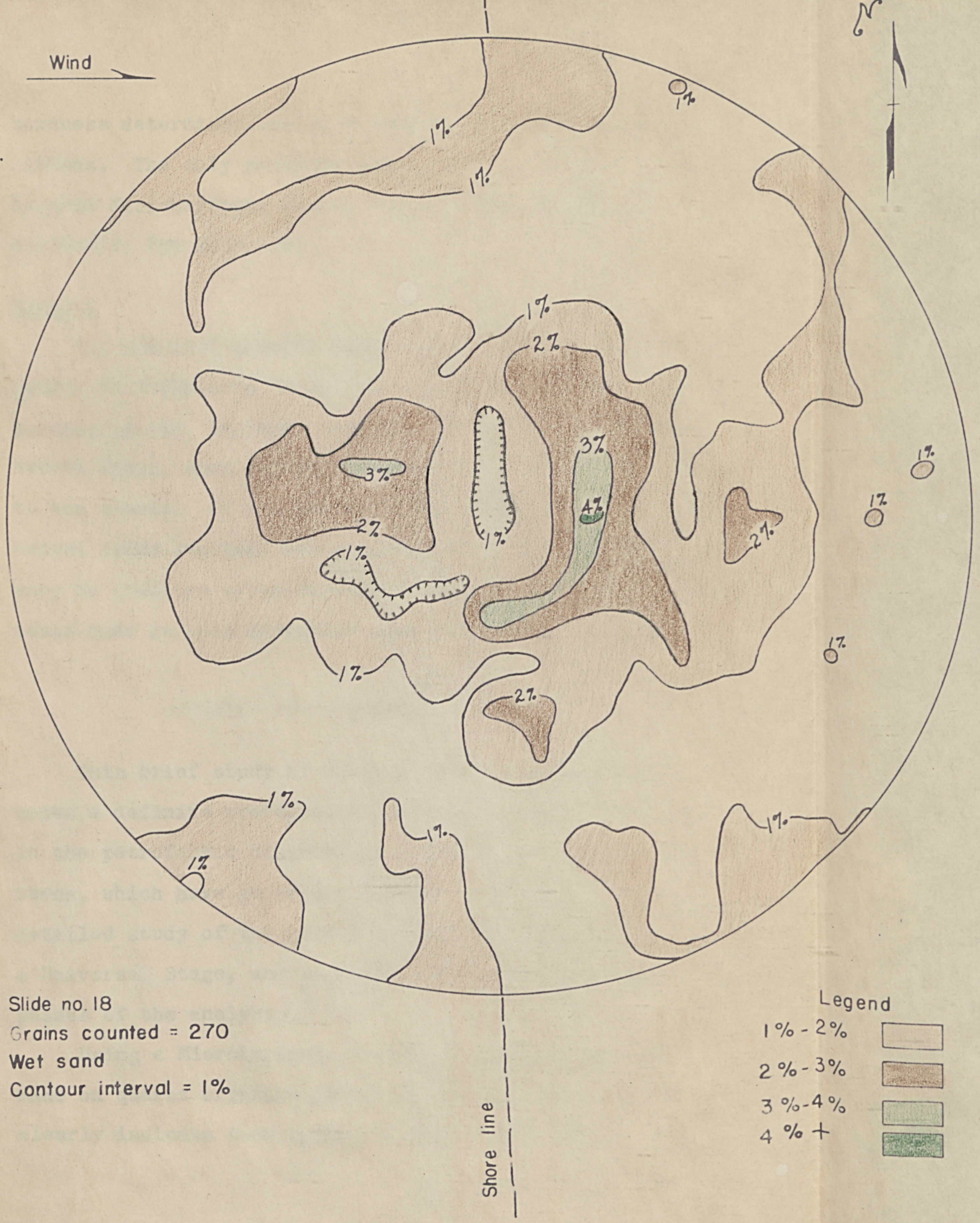
DIRECTIONAL HARDNESS STUDY OF QUARTZ CRYSTALS

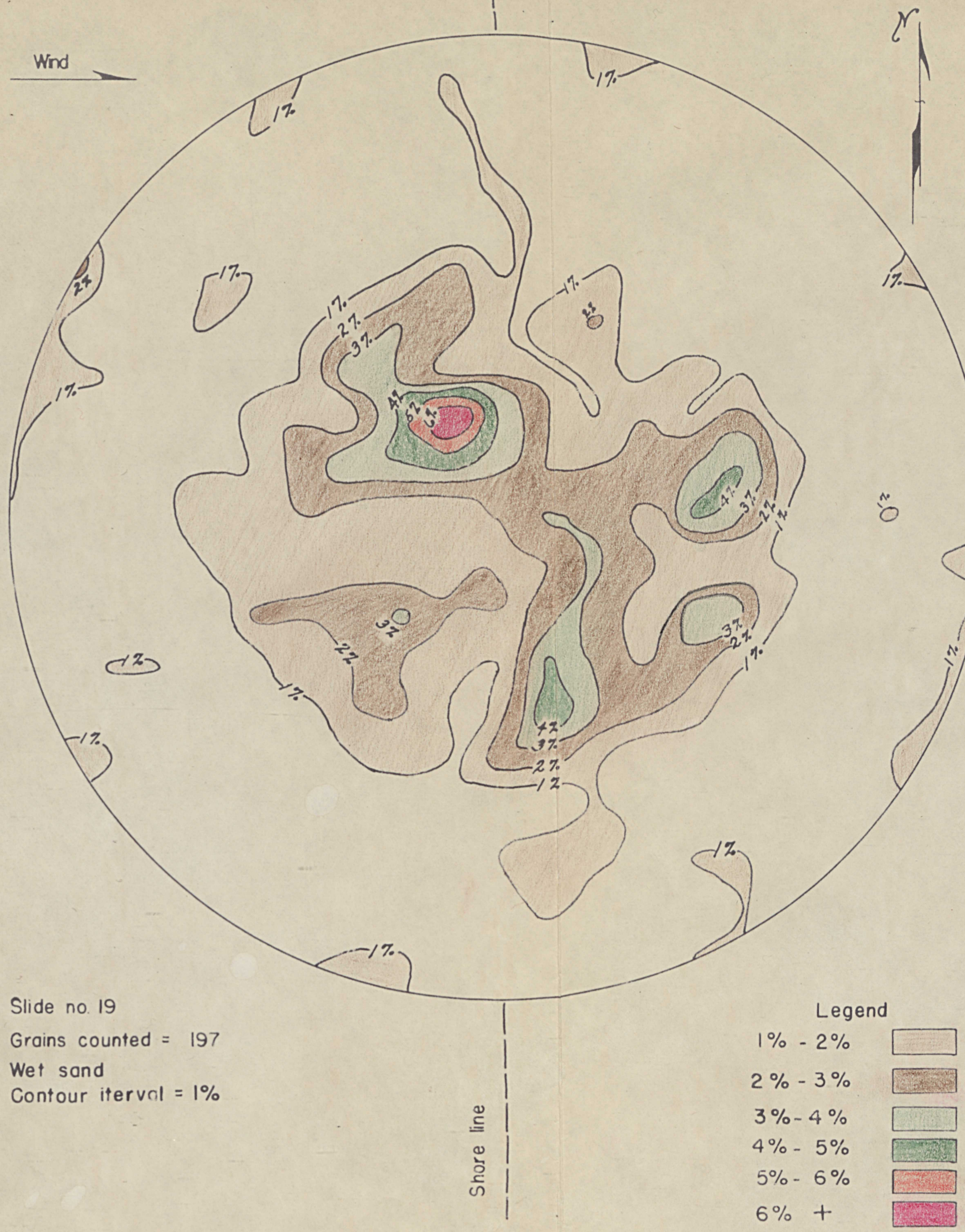
Preparation of Quartz Crystal Sections

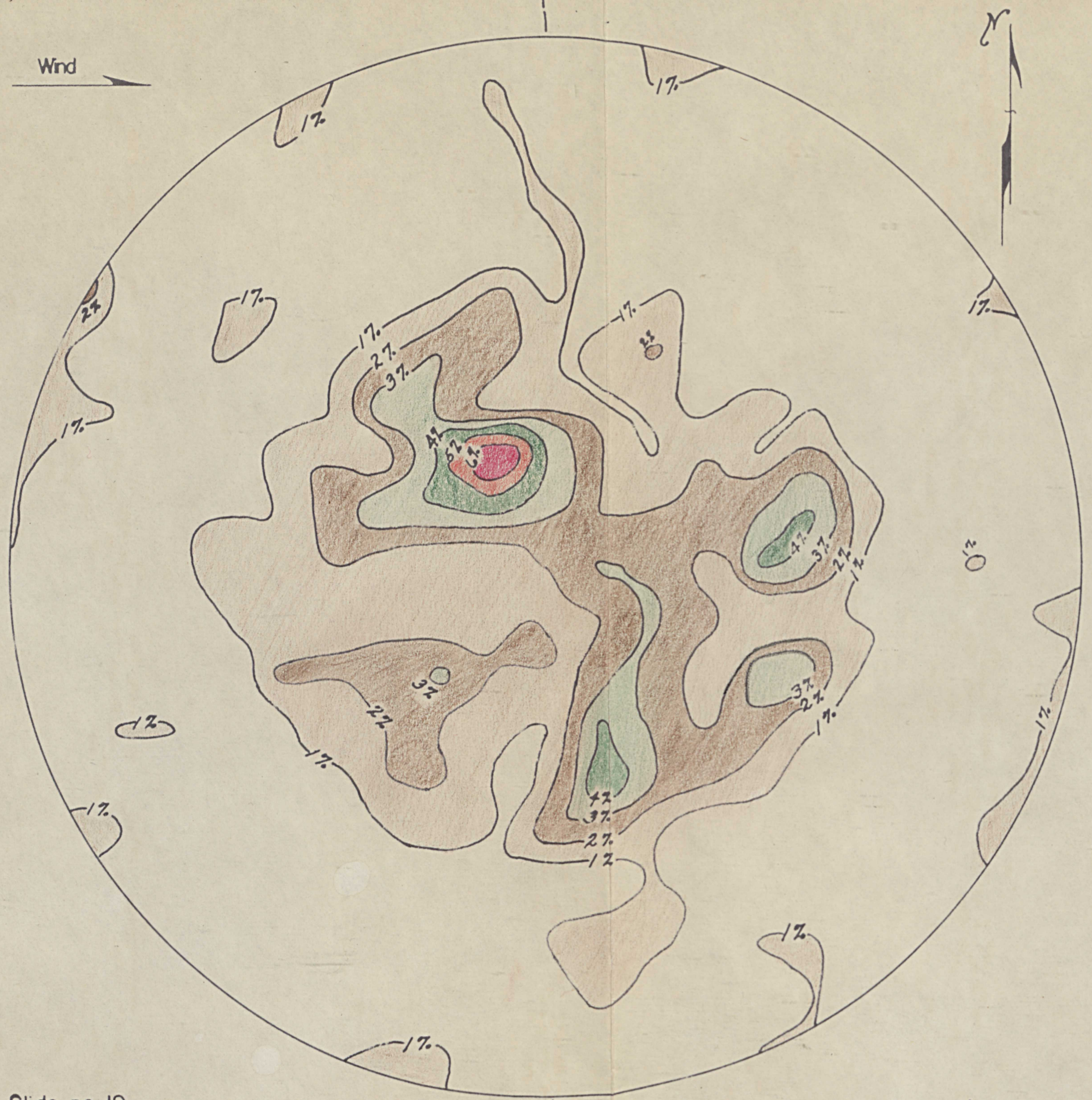
The crystals used for this study were cut and mounted on glass slides in three separate orientations. Sections of quartz were made (1) parallel to the c-axis, (2) perpendicular to the c-axis, and (3) parallel to the rhombohedral faces. These thick sections were then ground and polished to meet the specifications for testing.

Hardness Tester Technique

After the Microhardness Tester was set up and checked,


Wind
N
Slide no. 18
Grains counted = 270
Wet sand
Contour interval = 1%
Shore line
Legend
1% - 2%
2% - 3%
3% - 4%
4% +


Wind
N
Slide no. 19
Grains counted = 197
Wet sand
Contour itervol = 1%
Shore line
Legend
1% - 2%
2% - 3%
3% - 4%
4% - 5%
5% - 6%
6% +

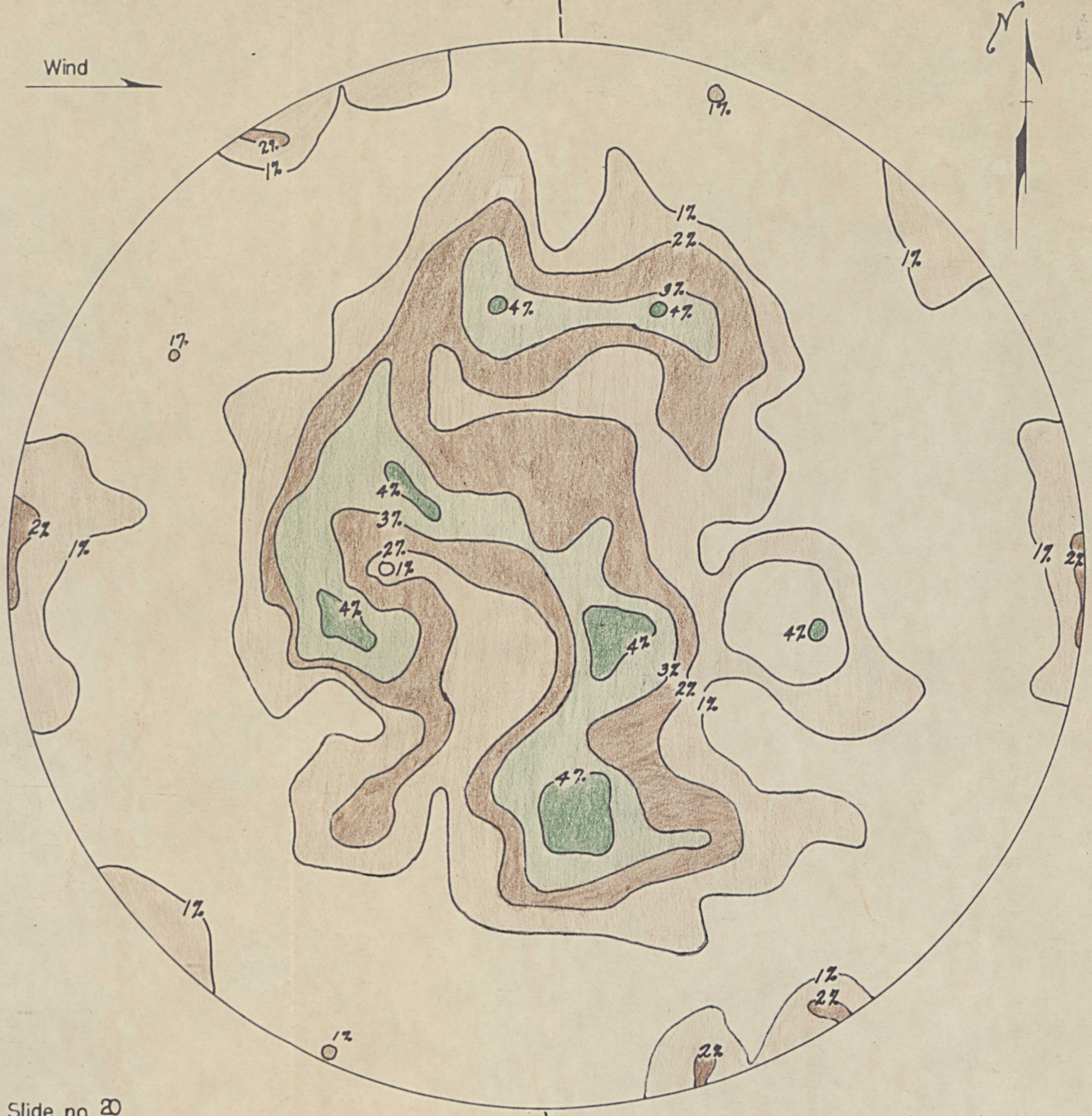


Slide no. 19
Grains counted = 197
Wet sand
Contour iterval = 1%

Shore line

Legend

1% - 2%	
2% - 3%	
3% - 4%	
4% - 5%	
5% - 6%	
6% +	



Slide no. 20
Grains counted = 225
Dry sand
Contour interval = 1%

Shore line

Legend

1% - 2%	
2% - 3%	
3% - 4%	
4% +	

hardness determinations were made according to established methods. The only previous geological application of the Kentron Microhardness Tester was by Forbes Robertson and William J. Van Meter (6).

Results

The results, clearly indicated in Fig. 2., show that quartz is definitely harder parallel to the c-axis. It was further proved, in tests made at right angles to rhombohedral faces, that the harder direction is at right angles to the c-axis. Of the two sections, parallel to the rhombohedral faces studied, one was found to have a definite tendency to fracture perpendicular to the c-axis. All of sixteen tests made in this direction show fracturing.

SUMMARY

This brief study of unconsolidated beach sands indicates a definite preferred orientation. High concentrations in the petrofabric diagrams represent broken girdle patterns, which have generally similar orientations. A detailed study of the quartz grains was made with the use of a Universal Stage, and standard procedures were used for all phases of the analysis.

Using a Microhardness Tester, a hardness analysis was made on quartz crystals in several orientations. Results clearly indicate that quartz is harder parallel to certain

TABLE OF HARDNESS VALUES FOR QUARTZ

Factors (the same for all tests):

Load - 100 grams

Objective - 4 mm.

Correction factor - .005

Objective factor - .1782

Tests:

(1) Polished surface perpendicular to quartz prism.

Filar unit readings (20).

220	193
204	216
208	220
233	211
213	223
212	209
211	223
205	218
220	206
238	228
	4311

Calculations:

4311 ÷ 20 = 216 Ave. Filar units.

216 x .1782 = 38.5 Lgth. in Microns.

9.600 from tables

9.600 x 100 = 960 KN*
- 5
955 KN/corr.

Results:

Quartz has a hardness of 955 KN parallel to the c-axis.

* Knoop Number

(2) Polished surface parallel to the c-axis.

Filar unit readings (20).

237	245
222	232
248	231
255	231
250	241
253	249
261	260
241	234
218	212
235	281
	4836

Calculations:

4836 ÷ 20 = 242 Ave. Filar units.

242 x .1782 = 43.1 Lgth. in Microns.

7.689 x 100 = 769 KN
- 4
765 KN/corr.

Results:

Quartz has a hardness of 765 KN perpendicular to the c-axis.

Figure No. 2

TABLE OF HARDNESS VALUES FOR QUARTZ (Cont.)

(3) Quartz section parallel to the c-axis on a rhombohedral face.

Filar unit readings (11).	Calculations:
260	2911 ÷ 11 = 264.6 Ave. Filar units.
270	
266	264.6 x .1782 = 47.1 Lgth. in Microns.
269	
247	6.415 x 100 = 641.5 KN
259	- 3.5
263	638.0 KN/corr.
270	
270	
286	
251	
2911	

Results:

Quartz has a hardness of 638.0 KN parallel to the c-axis on a rhombohedral face.

(4) Quartz section perpendicular to the c-axis on a rhombohedral face.

Filar unit readings (9).	Calculations:
221	2103 ÷ 9 = 234 Ave. Filar units.
233	
230	234 x .1782 = 41.7 Lgth in Microns.
226	
229	8.186 x 100 = 818.6 KN
241	- 3.6
248	815.0 KN/corr.
246	
2103	

Results:

Quartz has a hardness of 815.0 KN perpendicular to the c-axis.

Figure No. 2

optical axes, and that there appears to be a preference to fracture at right angles to the c-axis, through a rhombohedral face section.

CONCLUSION

There is a definite preferred orientation in the beach sands studied, which indicates that orientation must have been caused by differentially abraded grains and preferred fracturing. Differential abrasion is due to the difference in hardness of quartz in relative directions. But perhaps the most significant factor involves the apparent fracturing tendency of quartz at right angles to the rhombohedral faces. The normally expected stable orientation of a differentially abraded grain, is horizontal or nearly so, which should result in a peripheral petrofabric pattern; however, an apparent preferred fracturing could easily justify the patterns found. Therefore, summarily stated:

1. There is a definite preferred orientation of the beach sands studied.

2. Orientation is probably due to preferred fracturing and differential abrasion.

BIBLIOGRAPHY

(1) Wayland, Russell G., "Optical Orientation in Elongate Clastic Quartz," American Journal of Science, Vol. 237, Pp. 99-109. 1939.

(2) Rowland, Richard A., "Grain Shape Fabrics of Clastic Quartz," Geological Survey of America Bulletin, Vol. 57, Pp. 547-63, June, 1946.

(3) Ingerson, Earl, and Joseph L. Ramish, "Origin of Shape of Quartz Sand Grains," The American Mineralogist, Vol. 27, No. 9, Pp. 595-606, Sept., 1942.

(4) Fairbairn, Harold W., Structural Petrology of Deformed Rocks. Cambridge, Massachusetts: Addison-Wesley Press, Inc., 1942, P. 114.

(5) Knopf, Eleanora Bliss, and Earl Ingerson, "Structural Geology," Geological Survey of American Memoir 6, P. 238, Nov., 1938.

(6) Robertson, Forbes, and William J. Van Meter, "The Kentron Microhardness Tester, A Quantitative Tool in Opaque Mineral Identification," Economic Geology, Vol. 46, No. 5, Pp. 541-50, August, 1951.